

§18. A Basic Study on An Intensive Energetic Plasma Beam

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Efforts have been concentrated in construction of an intensive and energetic plasma beam of the power density as large as $\sim 10^4$ times to the usual neutral beam system, in which the ions are driven by the electro-static force. The accelerator engine under study is composed of the two major parts: the arcjet plasma source and the main $j \times B$ electro-magnetic (EM) beam driver. For the plasma source of an EM accelerator, the arcjet system must be the best one as is suggested by the theories on the solar wind 1,2). Actually, the theories call the essential requirements for successful EM plasma acceleration of the followings: the arcjet plasma source must ejects the flow of the speed greater than the thermal velocity of the plasma ions itself, since if the flow were sub-thermal the force acting along the stream works to decelerate the flow itself 2). It can be said therefore that construction of such an arcjet source as ejecting the super thermal flow must be the key issue for the intensive EM plasma accelerator. Failures of many trails in the past in many places for such a beam may be ascribed to the fact that the plasma sources applied were not always very adequate.

Detail analyses done so far are quite optimistic and predict that the energetic super thermal plasma flow may be generated if a cold gas is injected into the system properly 2). It is noted that if such process were done successfully, the final speed of the plasma flow achieves the velocity of the thermal speed of electrons, which is much larger than the ion thermal velocity or the minimum velocity for successful acceleration.

Experimental results on a z-pinch gun actually show that such a quite energetic flow is really produced if gas injection into the gun were done properly 3). The observed data by the particle energy analyzer show that the velocities of all the ion components including the impurities' take approximately the same value to the thermal velocity of electrons.

To extend the successful operations above into much longer time, use of the Laval nozzle may be convenient, since rapid pressure raise by arc ignition may be moderated by the shock wave formed somewhere in the nozzle. Here, two different nozzle wall shapes in Fig. 1 are tested: the one has long tapered wall and the other the short cone shape. For each type, gas injection properties are surveyed in some detail and summarized in Table 1. As is seen, the present system has potential to induce up to ~ 1500 A ion current equivalent. These data are from the pressure profile of the reservoir shown in Fig. 2. Here, the gas is fed to the reservoir impulsively by using the fast acting gas valve, which opens up and closes within 200 μ s.

On the downstream end of the nozzle, a straight arc channel is attached and the arc current of the value from 1000 to 2000 A is induced for production and acceleration of the plasma. The first target of the present work is in optimization of the system, which in other word

means that quite a simple but high power plasma beam system may be constructed.

Reference
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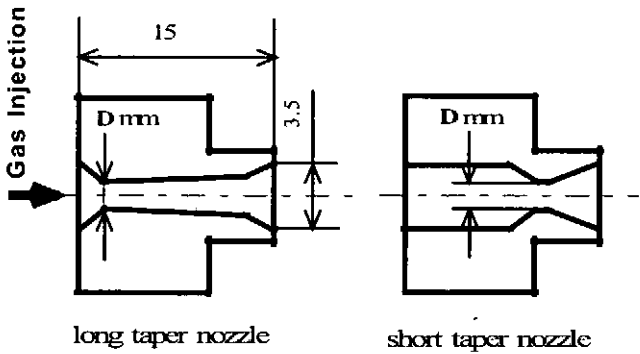


Fig. 1. Two types of the Laval nozzle tested. Each one has three different throat diameters D. The one in the left has a slowly enlarging tapered nozzle toward the arc channel in the downstream where the plasma production and acceleration are done simultaneously. The other one in the right has a rather abrupt short throat opening.

Long Taper Nozzle		Short Taper Nozzle	
D throat	I Equivalent	D throat	I Equivalent
0.8 mm	1000 A	0.8 mm	720 A
1.0 mm	1300 A	1.0 mm	1500 A
1.2 mm	1500 A	1.2 mm	1500 A

Table 1. Measured hydrogen gas current equivalent I through each nozzle as a function of a throat diameter for the inlet gas reservoir pressure profile in Fig.2

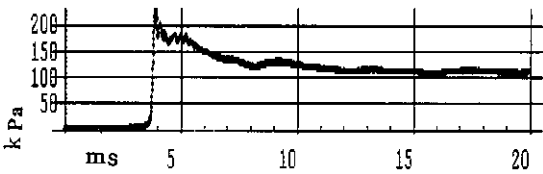


Fig. 2. A typical pressure profile of the gas reservoir placed on the upstream side of the nozzle.